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## **Advanced tuning algorithms for high-frequency SIS mixers**

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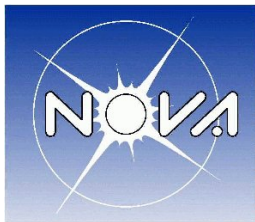
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# Advanced Tuning Algorithms for High-Frequency SIS Mixers



NOVA Sub-mm  
Instrumentation  
Group



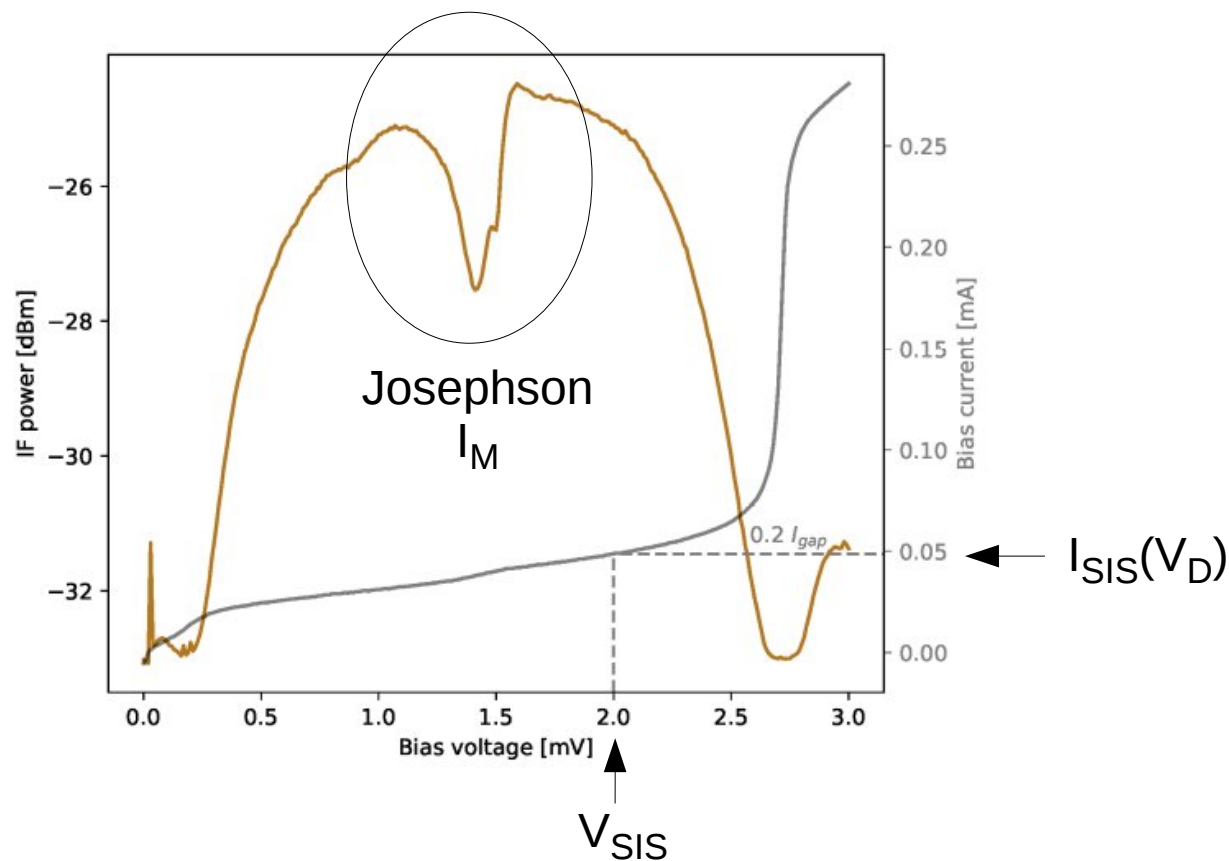
kapteyn astronomical  
institute

Ronald Hesper  
Jan Barkhof  
Tobias Vos  
Andrey Baryshev

# Tuning SIS mixers

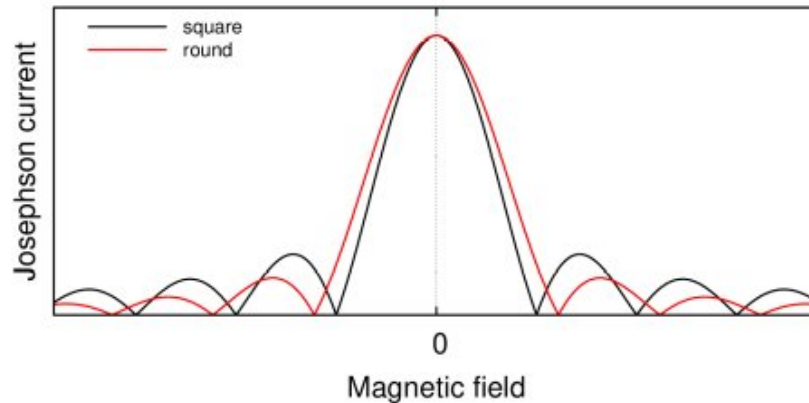
The main tuning parameters of SIS mixers:

- Bias voltage ( $V_{\text{SIS}}$ )
- Bias current ( $I_{\text{SIS}}$ ), set by LO power ( $V_{\text{D}}$ )
- Josephson suppression, set by magnetic field ( $I_{\text{M}}$ )

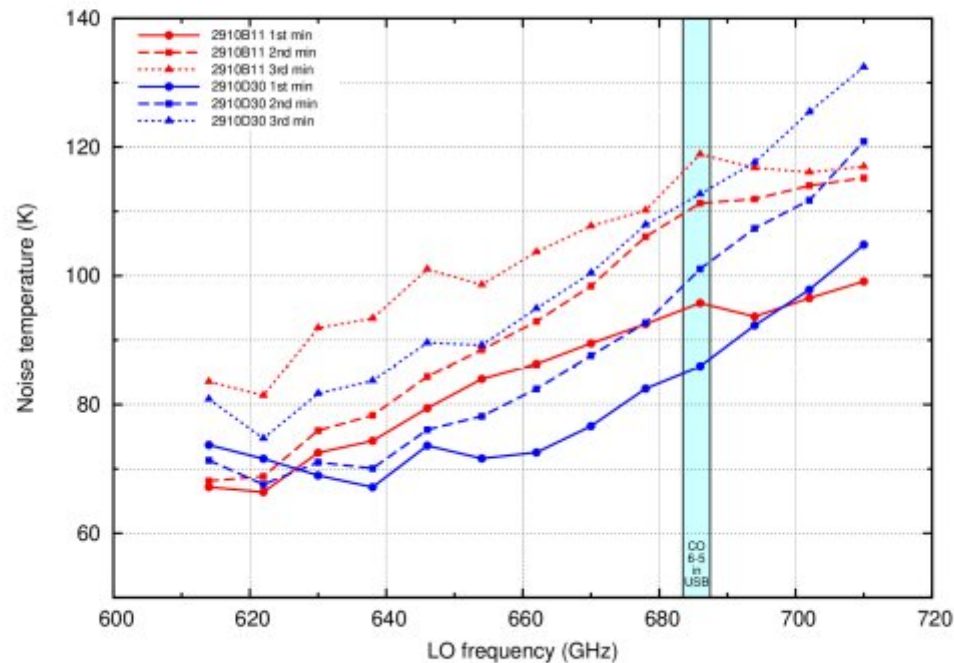
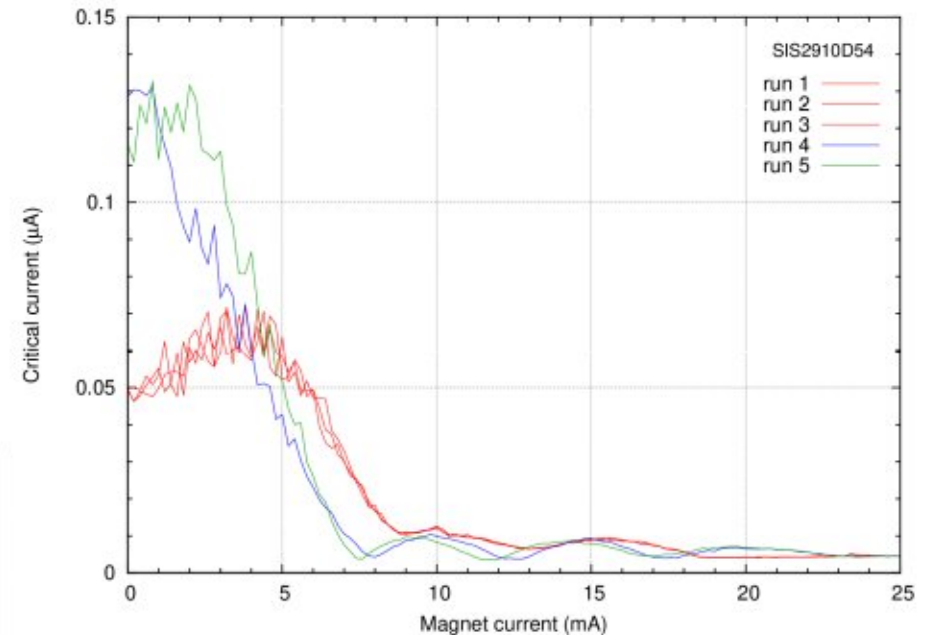


# Josephson suppression

Ideal



Reality: multiple states, hysteresis



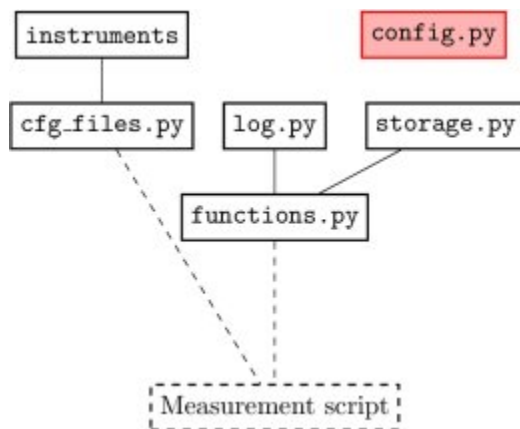
Delivered tunings: usually 2<sup>nd</sup> minimum

Significant noise temperature improvement possible in many (most?) mixers going to first minimum

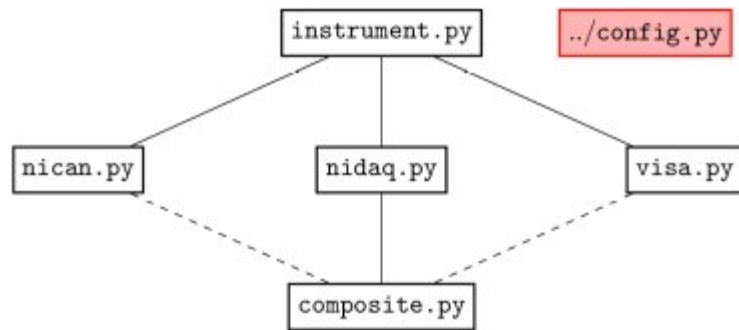
# Software infrastructure

The engineering software package (“Rodrigo”) used for Band 9 and Band 5 qualification is not suitable as-is for adaptive algorithms (no conditionals or loops).

→ new Python-based engineering package (“NOVASoft”)



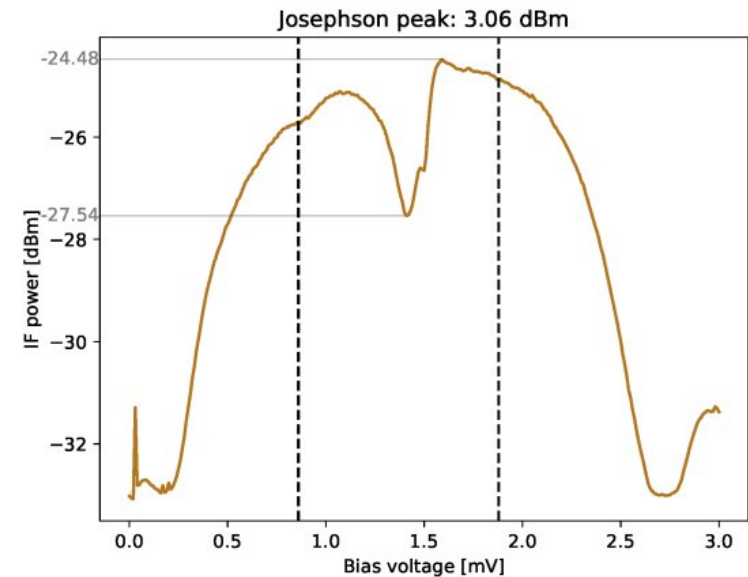
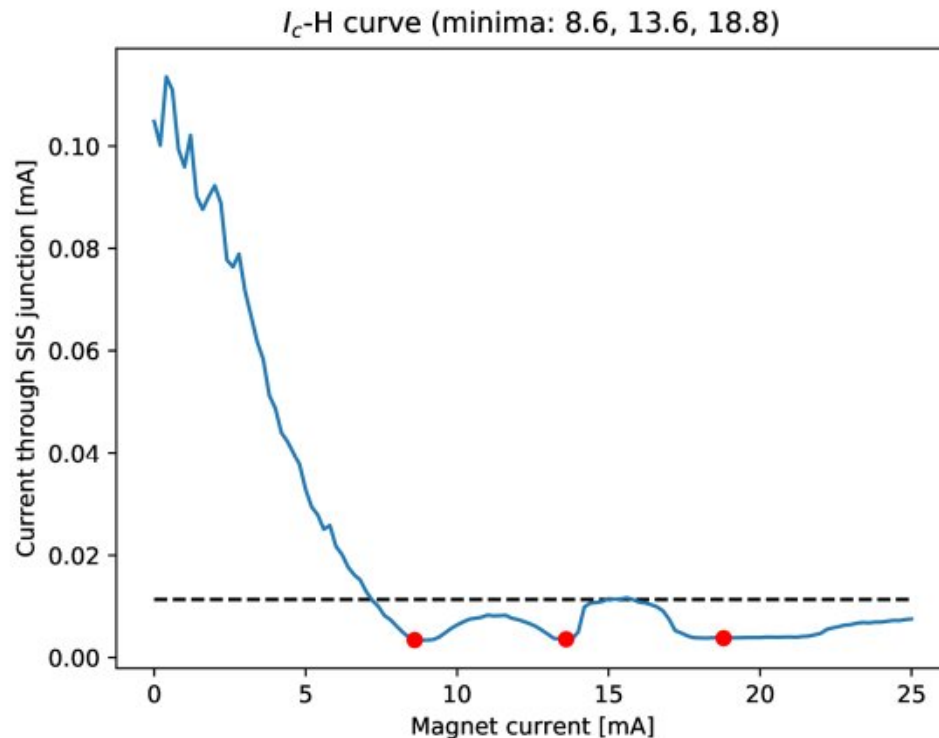
Top-level structure



Structure of instrument sub-package

- Maintains “look & feel” of Rodrigo (configuration, file formats, basic scripts)
- ... but unlocks full programming language facilities
- Open source (GPL)

# Automating human decisions



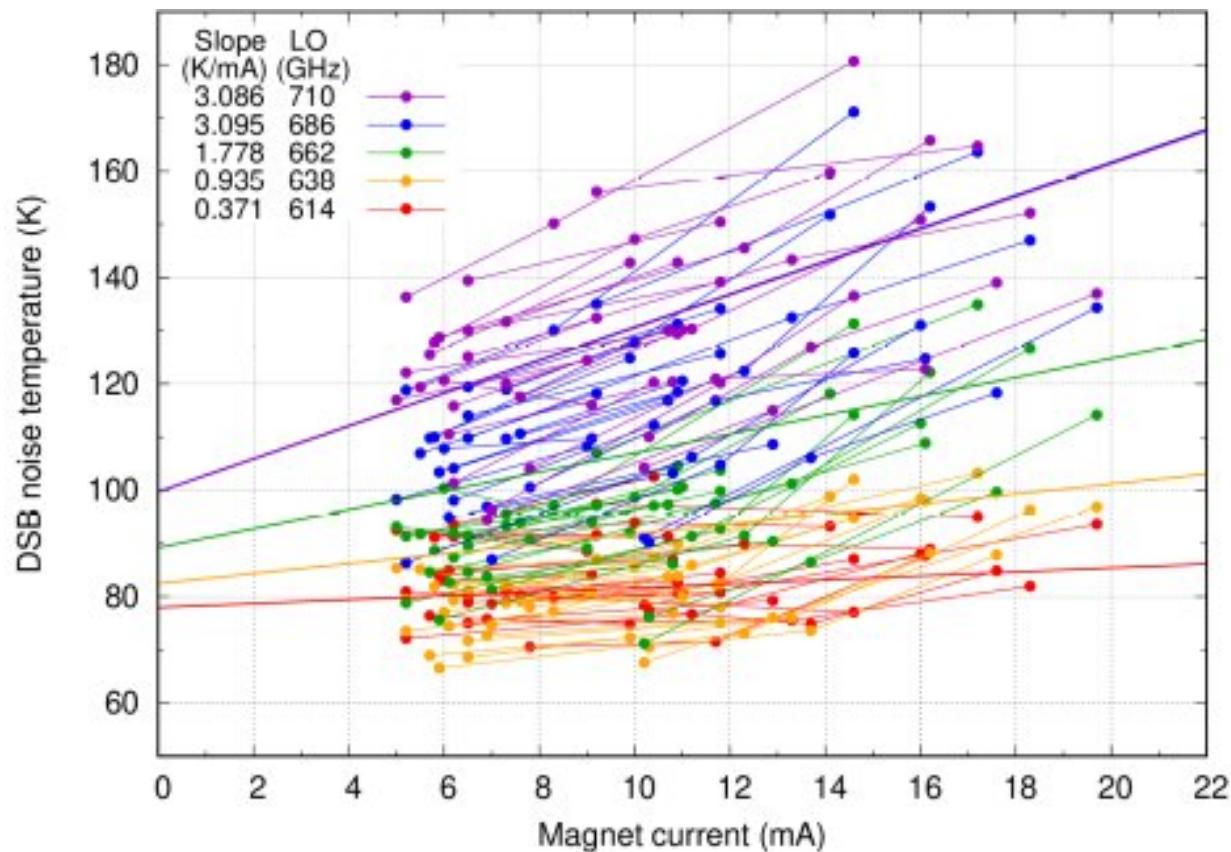
Formerly, the minima were found by eye. The new algorithm finds them by filtering and differentiating, within limiting values.

There are several parameters to tweak in order to get reliable identification of minima → should be tested on sufficient #mixers

The suppression can be verified by the p-p range of the Josephson structure in the power curve.

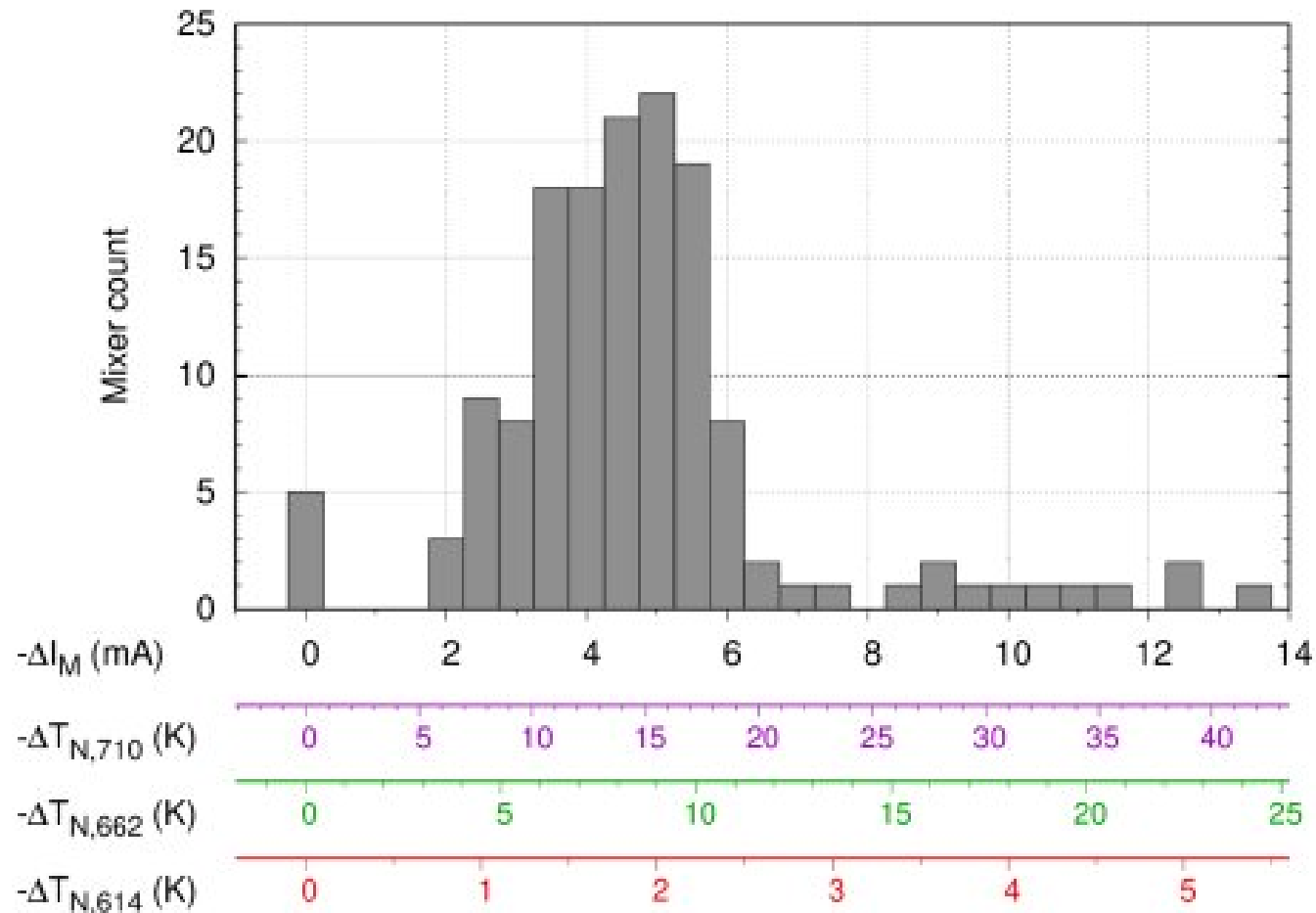
# How many mixers can be improved? By how much?

For CHAMP+ upgrade  $\approx 20$  AlN SIS junctions were re-measured  
*In both 1<sup>st</sup> and 2<sup>nd</sup> minima (sometimes 3<sup>rd</sup>)*



Averaged slopes of 1<sup>st</sup>-to-2<sup>nd</sup> minima lines, for 5 LO frequencies

# Expected improvement for ALMA



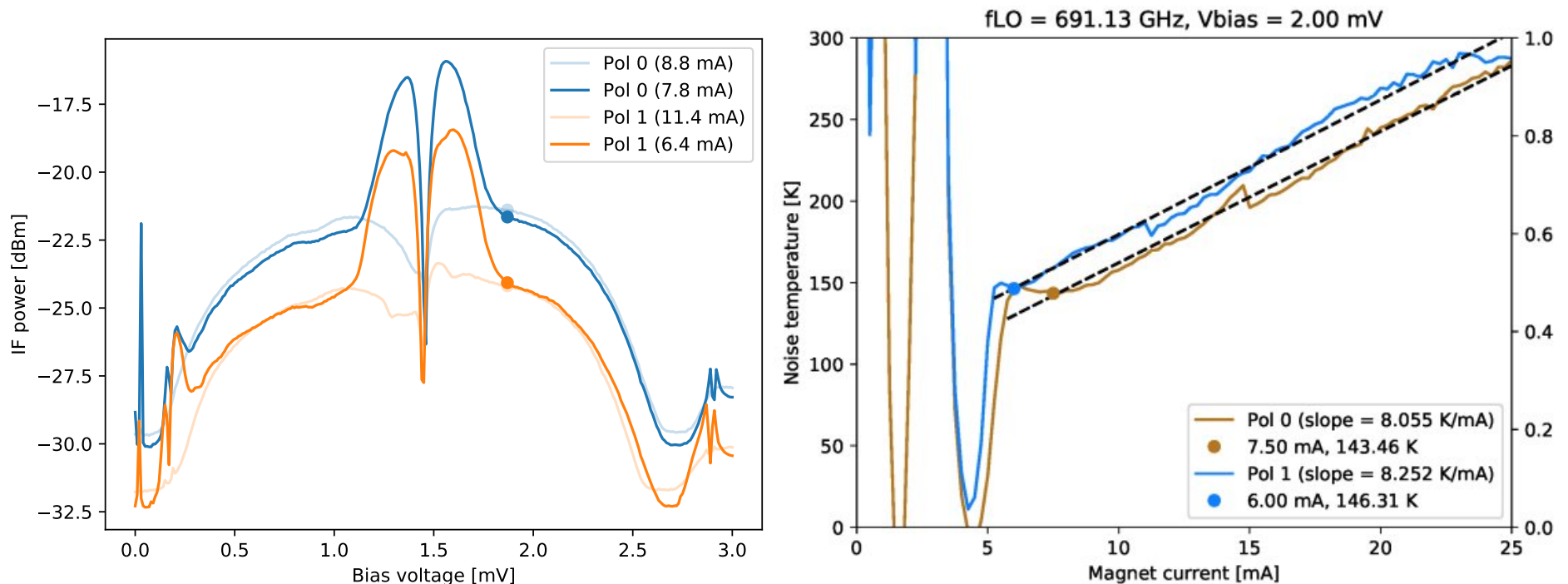
At the high end of the band (e.g., CO 6-5), about 10-15% noise temperature could be shaved off → 5-7 antennas for free!



# H-field dependence of the noise temperature

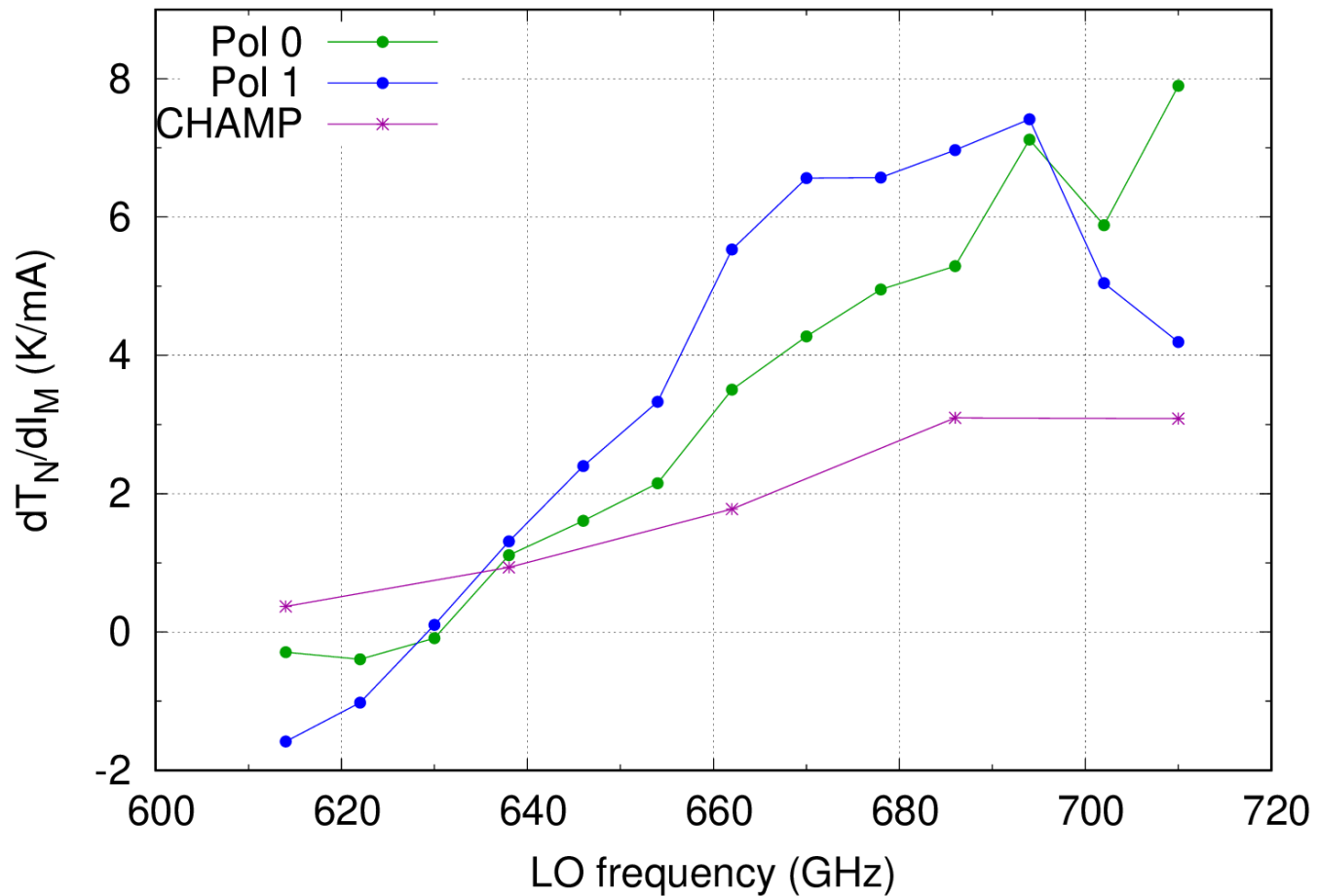
Question: what actually determines the noise temperature:

- The magnetic field?
- The supercurrent?



As long as the bias voltage stays out of the Josephson region, there is a straight relationship between  $T_N$  and  $I_M$ , no sign of minima.

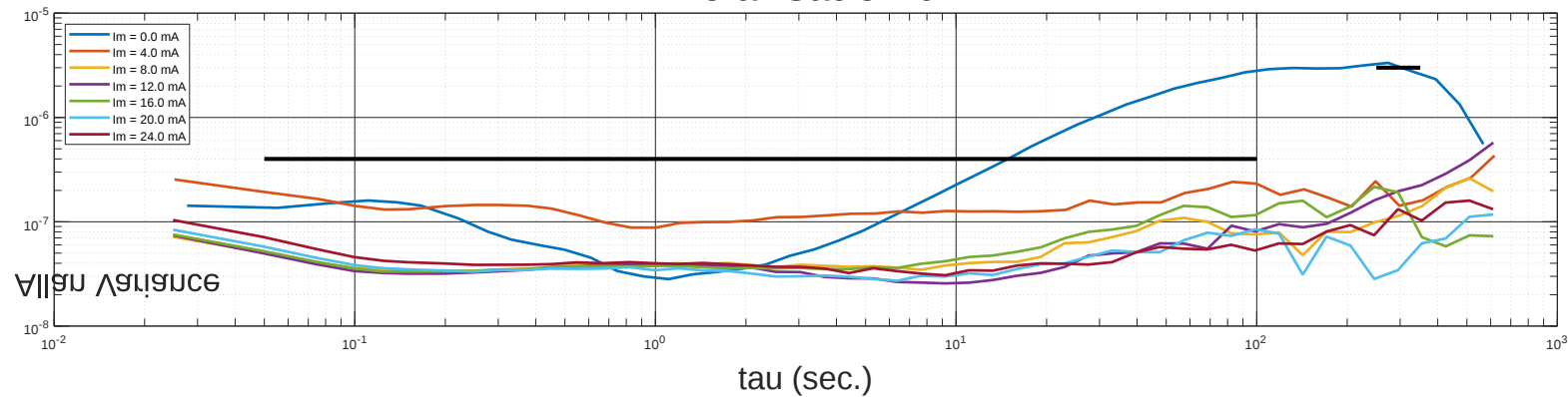
# $T_N$ vs. $I_M$



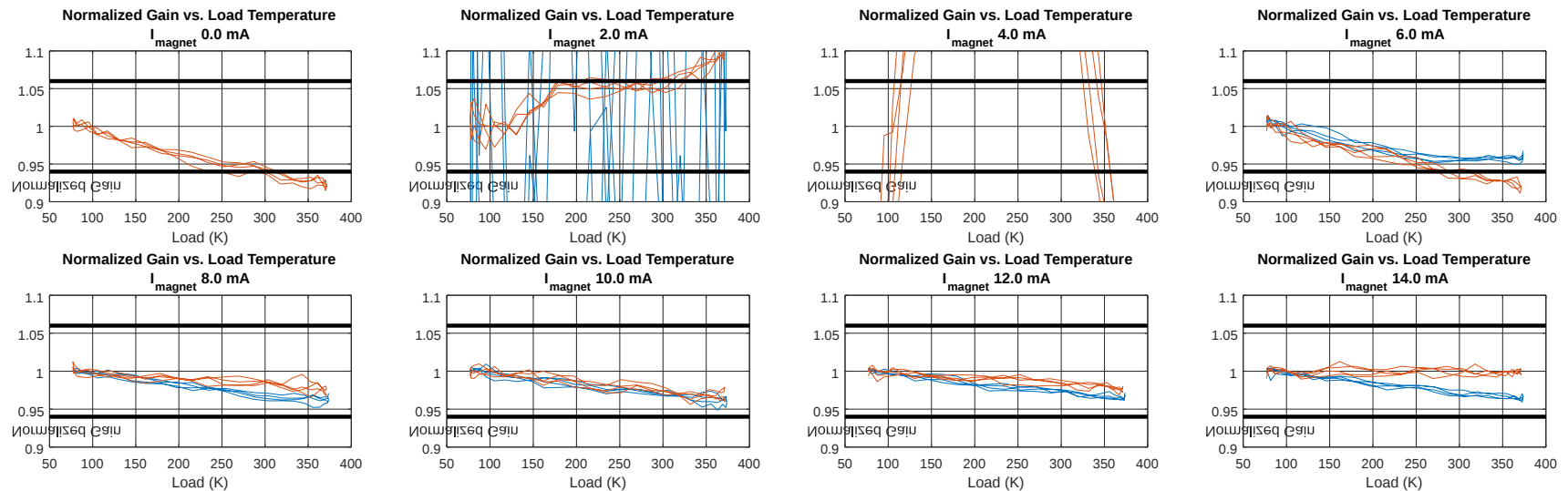
Discrepancy between CHAMP data and recent measurements  
Tuning? To be investigated

# Do other performance properties suffer from low magnet current?

Allan Variance Total power for different magnet currents  
Polarisation 0



## Compression



# Conclusions

A new engineering software infrastructure was developed, with full higher-level language facilities.

The traditional “by eye” optimizations for SIS voltage, pumping level and Josephson suppression were automated.

For a good suppression, it is not necessary to go to a minimum in critical current. The lowest current giving good stability and compression level should be usable in most cases.

The existing ALMA Band 9 mixers can probably be improved by 10-15% on average, yielding a performance increase worth several antennas.